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13. SUPPLEMENTARY NOTES The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.					
14. ABSTRACT We have completed the purchase of a medium and high-frequency (MF/HF, 0.3 to 30 MHz) radio receiving system for the Interamerican University Aguadilla Campus in northwest Puerto Rico. The system has five primary uses: (1) Direction-finding radio emission observations and radar imaging studies of the ionosphere. (2) Imaging and spectral and temporal study of ionospheric radio emissions. (3) Oblique-angle radio emission observations and multiple bistatic radar observations. (4) Development and application of novel antenna techniques. (5) Use in a wide range of inspiring high school and university level student projects.					
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16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	15. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON Brett Isham
a. REPORT UU	b. ABSTRACT UU	c. THIS PAGE UU			19b. TELEPHONE NUMBER 787-685-5223

Report Title

Final Report: A Multiple Use MF/HF Radio Array for Radio Research, Development, and Education

ABSTRACT

We have completed the purchase of a medium and high-frequency (MF/HF, 0.3 to 30 MHz) radio receiving system for the Interamerican University Aguadilla Campus in northwest Puerto Rico. The system has five primary uses: (1) Direction-finding radio emission observations and radar imaging studies of the ionosphere. (2) Imaging and spectral and temporal study of ionospheric radio emissions. (3) Oblique-angle radio emission observations and multiple bistatic radar observations. (4) Development and application of novel antenna techniques. (5) Use in a wide range of inspiring high school and university-level student projects.

Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

<u>Received</u>	<u>Paper</u>
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TOTAL:

Number of Papers published in peer-reviewed journals:

(b) Papers published in non-peer-reviewed journals (N/A for none)

<u>Received</u>	<u>Paper</u>
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TOTAL:

Number of Papers published in non peer-reviewed journals:

(c) Presentations

An MF/HF antenna array for radio and radar imaging of the ionosphere. Brett Isham, Terence Bullett, Bjørn Gustavsson, Vasyl Belyey. USNC-URSI National Radio Science Meeting (NRSN). Boulder, Colorado, USA, 6–9 January 2016.

Stories from the past year and what they say about the future.

Brett Isham.

A Workshop to Consider the Future of Radio and Space Physics.

Ithaca, New York, USA, 30 March - 1 April 2015.

Invited.

Number of Presentations: 1.00

Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):

(d) Manuscripts

Received Paper

TOTAL:

Number of Manuscripts:

Books

Received Book

TOTAL:

Received

Book Chapter

TOTAL:

Patents Submitted

Patents Awarded

Awards

The PI is an invited member of the scientific organizing committee for the 2016 COSPAR (Committee on Space Research, part of the International Council for Science) General Assembly, 30 July - 7 August 2016, session C5.1D4.1, on Active Space Experiments.

The PI was an invited speaker at one conference:
Stories from the past year and what they say about the future.
Brett Isham.
A Workshop to Consider the Future of Radio and Space Physics.
Ithaca, New York, USA, 30 March - 1 April 2015.
Invited.

Graduate Students

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
FTE Equivalent:	
Total Number:	

Names of Post Doctorates

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
FTE Equivalent:	
Total Number:	

Names of Faculty Supported

<u>NAME</u>	<u>PERCENT SUPPORTED</u>	National Academy Member
Brett Isham	0.00	
FTE Equivalent:	0.00	
Total Number:	1	

Names of Under Graduate students supported

<u>NAME</u>	<u>PERCENT SUPPORTED</u>	Discipline
Gaith Mohammad	0.00	computer science
Hector Ortiz-Colon	0.00	computer science
FTE Equivalent:	0.00	
Total Number:	2	

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period: 0.00

The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:..... 0.00

Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):..... 0.00

Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense 0.00

The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields:..... 0.00

Names of Personnel receiving masters degrees

<u>NAME</u>
Total Number:

Names of personnel receiving PHDs

<u>NAME</u>
Total Number:

Names of other research staff

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
FTE Equivalent:	
Total Number:	

Sub Contractors (DD882)

Inventions (DD882)

Scientific Progress

We have completed the purchase of a medium and high-frequency (MF/HF, 0.3 to 30 MHz) radio receiving system based at the Inter American University Aguadilla Campus in northwest Puerto Rico.

The radio receiving system will have three main operational modes:

A 300-m array configuration used as a bistatic radio imaging receiver for transmissions from the VIPIR HF radar located in Cayey, Puerto Rico, for studies of phenomena such as atmospheric gravity waves, plasma irregularities, and space weather monitoring.

A 12-km array configuration for imaging the structure of stimulated radio emissions (SEE) from the HF interaction region above Arecibo Observatory, with the goal of determining the exact geometries of the source regions of the many SEE spectral features with respect to the geomagnetic field.

A 100-km array configuration used with the VIPIR radar for studies of large-scale ionospheric structure and for multi-point oblique-angle observations of radio emissions during Arecibo HF experiments, to study the aspect angle dependence of the plasma turbulence.

All three arrays are designed to measure the frequency-dependence of the polarization of radio emissions. Observations of the geometric and polarization properties of radio emissions using these arrays will drive the development of new radio techniques and technologies.

Technology Transfer

The project is a novel implementation of a medium and high-frequency radio system previously used for radar reception at a number of sites worldwide. The new aspects are the requirement for imaging, and the larger size of the array, which requires careful consideration of timing between receivers, and new methods of instrument calibration. Discussions with the equipment vendors have been helpful, but the bulk of the technical development has been at the university, with technology transfer to the vendors.